

Ultra Low Freezer Performance and Energy Use

**Thermo Scientific
Revco
Model UXF 500 86D**

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Product Website:

http://www.thermoscientific.com/ecom/servlet/productsdetail_11152_L10429_80523_14018602_-1

<https://fscimage.thermoscientific.com/images/D02645~.pdf>

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Introduction

The energy intensity of laboratories has come into focus over recent years, and Labs21 has provided a website to publish this data. As well, building designers are looking for new ways to reduce building plug load and cooling from reject heat. The energy consumption of water cooled freezers is lower than air cooled units, and reject heat is shed into process cooling loops.

During October, 2011 staff and students from the office of Environmental Stewardship and Sustainability tested three ultra low freezers (ULF, Tables 1 and 2). The manufacturers kindly shipped, helped install the freezers and advised this project. Without their enthusiastic participation it could not have occurred and we are very grateful. The results from the Revco freezer testing are presented here.

Distributor	Thermo
Manufacturer	Revco
Model	UXF 500 86D
Face Width (")	38
Door Swing Min. (")	5
Cubic Feet	24.1
2" Boxes	500
Boxes/Linear Foot	140

Table 1. Ultra Low Freezer dimensions and capacities.

Distributor	Thermo
Manufacturer	Revco
Outer Door Hinge	3 ea Barrel, 20 cm
Door Swing	180°
Outer Door	4"
Latch	Cam lock, manual
Gaskets	On door, 4 closed tubes
Inner Doors	Insulated
Vacuum Relief	Included
Noise	NA

Table 2. Freezer Construction and Doors.

Testing methods

Energy

We used Elite Pro energy meters on loan to UC Davis from the Pacific Gas and Electric Tool Lending Library, set up with 15 Amp current transducers (CT's). Split cord pigtails provided single conductors for CT placement, or CT's were placed over single conductors inside the mechanical cabinet. All three freezer amperages were measured simultaneously to obtain Volt-Amp values. Power factor was measured individually on each freezer by attaching voltage clips in a bare wire outlet box before energizing and then insulated, thus avoiding live connection hazards. We multiplied Volt-Amps by the power factors to calculate Watts during subsequent tests. Freezers were allowed to stabilize at each temperature for 6 –10 hours, then energy measurements were logged either at 1 minute or 5 minute intervals and averaged over at least 8 hours. Freezers were tested without samples.

Temperature

On the recommendation of cryo-temperature experts in the UC Davis Physics Department, we selected type J thermocouple (TC) wire for temperature sensing. We cut and welded 13 TC's at either 3 or 5 meters, and attached them to type J plugs. They were inter-calibrated for precision in a methanol bath with dry ice chunks and stirring. Three TC's were measured during both calibration sessions and averaged. Offsets from these averages were calculated for each TC and were applied to temperature readings, (Appendix B).

Up to eight TC's were logged simultaneously using an Omega TC-08 panel. Two TC's were placed in each ULF, one next to the installed temperature probe, and one in the geometric center of the cabinet, about 4 cm above the shelf. Intake air temperature was logged on the intake grill. Occasional room temperature measurements were made with an infrared thermometer, and room temperature was 23.0 +/- 0.3 C.

Results

Temperature Characteristics

The purpose of this test was not detailed assessment of spatial and temporal uniformity. Some data was collected from the two TC's in the middle of the freezer and next to the sensor, (Table 3). As seen in Figure 2, temperatures at the sensor were generally warmer by about 2° than temperatures at the middle of the freezer, and there was over 4 degrees range with time.

	Thermo
Mean	-80.5
Max-Min	4.49
Measured - Set Point	-0.53
Sensor - Middle	-2.14

Table 3. Temperature values over time and uniformity in the cabinet, (set point -80 degrees).

Energy Consumption

The Revco UBX freezer consumed about 19 kWh/d, (Table 4). Energy consumption in the energy savings mode was calculated at 15% less than measured high-performance values. The energy intensity per box and cubic foot are also listed.

	Revco	Revco Eco Mode
Energy Use kWh/d	19.1	16.2
Power Factor	0.95	0.95
Energy Intensity (W/CF)	33.0	28.1
Energy Intensity (W/Box)	1.59	1.40
Electricity Cost/y (8.5 c/kWh)	\$ 593	\$ 504
Electricity Cost/Box/y	\$ 1.19	\$ 1.01

Table 4. Energy consumption and intensity at the set point -80 °C.

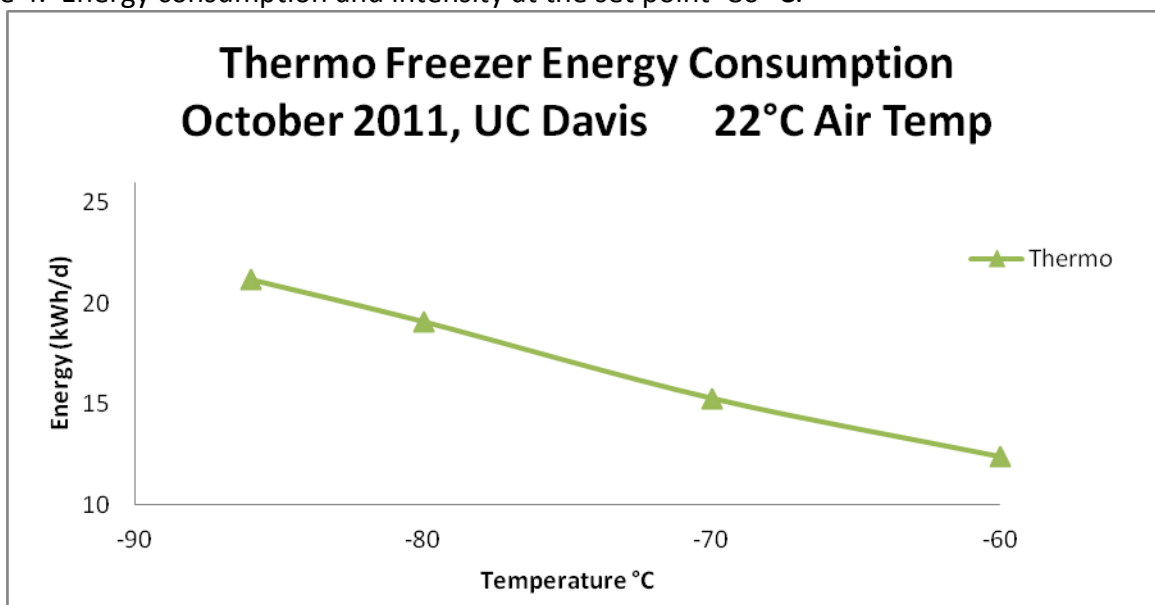


Figure 1. Energy consumption of Thermo ultra low freezer at four set points.

Appendices.

A) Complete temperature measurements and deviations.

Mean Temperature Measured at Sensor

-80 -80.0

Mean Temperature Measured at Middle

-80 -81.0

Sensor °C - Middle °C

-80 -2.14

Range Max-Min

-80 4.49

Sensor °C -Set Point

-80 -0.53

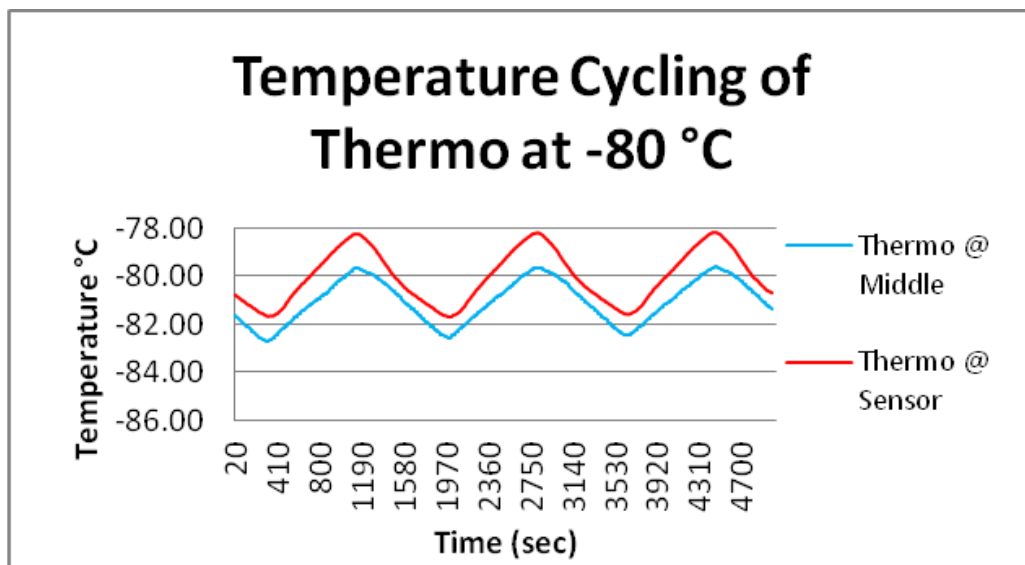
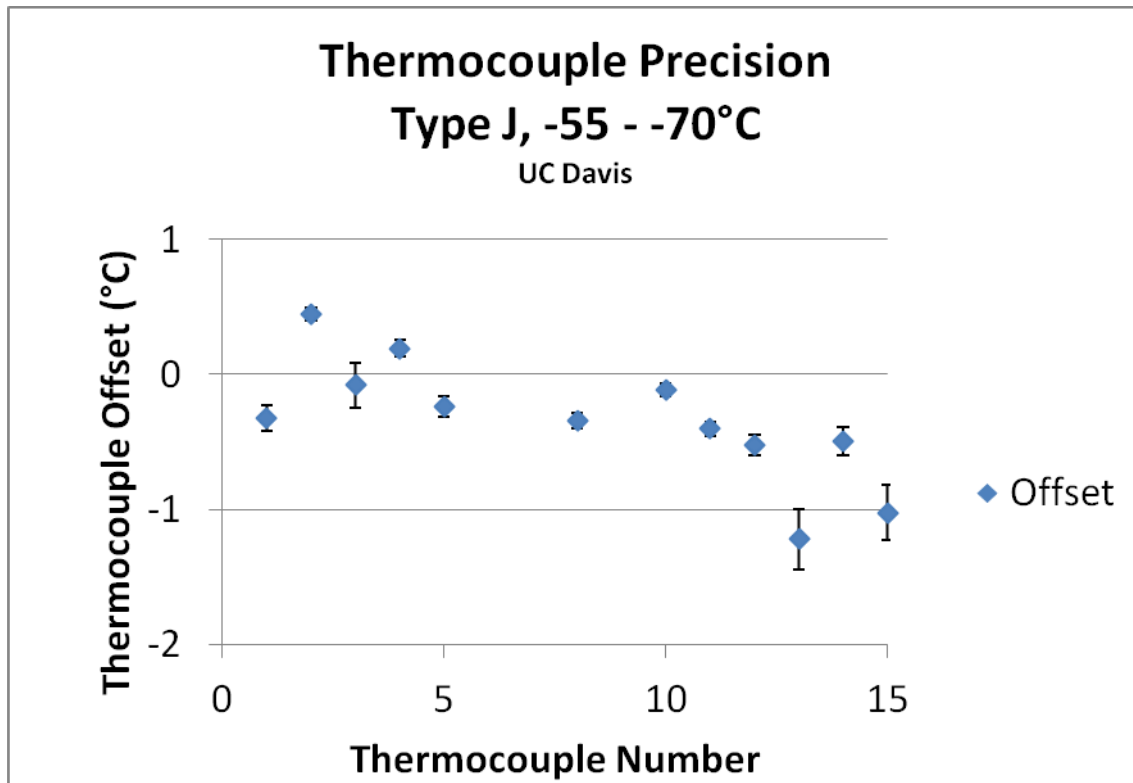
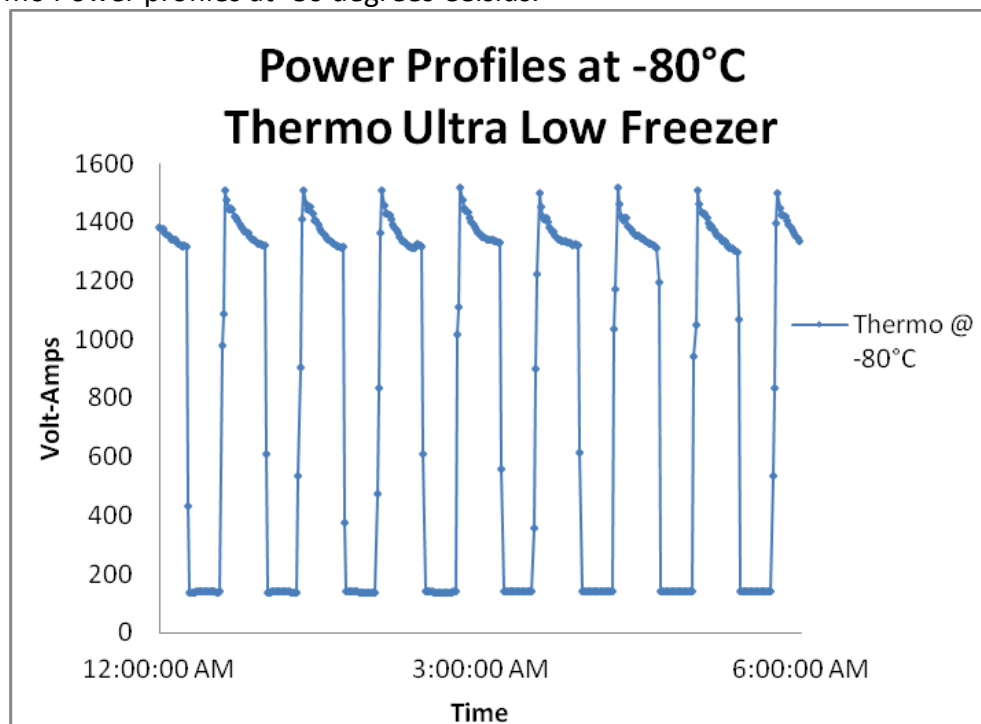


Figure 2. Temperature cycling shows that temperatures at the middle of the freezer were about 1° colder than temperatures at the sensor

- B) Thermocouple Precision measured in methanol and dry ice bath. The thermocouples were generally within 0.5 °C, though two were a degree or more from a mean of four TC's. Offsets were applied to each thermocouple's data.



- C) Thermo Power profiles at -80 degrees Celsius.



D) Example data at -80 degrees Celsius logged by the Elite Pro logger at -80 °C set point.

Date	End Time	Avg. Volt	Avg. Amp	Avg. PF
9/28/2011	0:00:00	205	6.75	-0.52
9/28/2011	0:01:00	205	6.72	-0.52
9/28/2011	0:02:00	205.2	6.7	-0.51
9/28/2011	0:03:00	205.3	6.65	-0.51
9/28/2011	0:04:00	205.3	6.61	-0.51
9/28/2011	0:05:00	205.1	6.61	-0.51
9/28/2011	0:06:00	205	6.58	-0.51
9/28/2011	0:07:00	205	6.54	-0.51
9/28/2011	0:08:00	205	6.53	-0.51
9/28/2011	0:09:00	204.7	6.54	-0.51
9/28/2011	0:10:00	204.3	6.51	-0.51
9/28/2011	0:11:00	203.8	6.5	-0.51
9/28/2011	0:12:00	203.8	6.49	-0.51
9/28/2011	0:13:00	204	6.46	-0.51
9/28/2011	0:14:00	204.1	6.47	-0.51
9/28/2011	0:15:00	204.1	6.45	-0.51
9/28/2011	0:16:00	204	2.12	-0.47
9/28/2011	0:17:00	204.1	0.68	-0.34
9/28/2011	0:18:00	204.2	0.68	-0.34
9/28/2011	0:19:00	204.1	0.68	-0.34
9/28/2011	0:20:00	204.1	0.68	-0.34
9/28/2011	0:21:00	204.8	0.68	-0.34
9/28/2011	0:22:00	205	0.68	-0.34
9/28/2011	0:23:00	205	0.68	-0.34
9/28/2011	0:24:00	205	0.68	-0.34
9/28/2011	0:25:00	205	0.68	-0.34
9/28/2011	0:26:00	204.9	0.68	-0.34
9/28/2011	0:27:00	204.8	0.68	-0.34
9/28/2011	0:28:00	204.8	0.68	-0.34
9/28/2011	0:29:00	204.9	0.68	-0.34
9/28/2011	0:30:00	205.1	0.68	-0.34
9/28/2011	0:31:00	204.6	0.68	-0.34
9/28/2011	0:32:00	204.1	0.68	-0.34
9/28/2011	0:33:00	203.9	0.68	-0.34
9/28/2011	0:34:00	204.1	0.69	-0.35
9/28/2011	0:35:00	204.2	4.8	-0.52
9/28/2011	0:36:00	204.3	5.33	-0.51
9/28/2011	0:37:00	204.4	7.38	-0.51
9/28/2011	0:38:00	204.4	7.22	-0.51
9/28/2011	0:39:00	204.4	7.06	-0.51